Algorithms and Static data structures
Series of exercises number 01
October 2024

Exercise 1: Greatest number

Statement

Write an algorithm that finds the greatest number amongst N given integers. For example, amongst the numbers 3, 5, 7, 2, the greatest is 7.

Objectives

- Analyze the problem.
- Write the pseudo-code algorithm.
- Define the Processor.
- Define the Environment.
- Validate the algorithm.

Exercise 2: Enigma of the three water tanks

Statement

Let consider three water tanks:

- A tank of 8 liters (full).
- A tank of 5 liters (empty).
- A tank of 3 liters (empty).

Objectives

The objective is to write an algorithm to distribute exactly 4 liters of water into the 5-liter tank. The only possible actions are to transfer water between tanks, fill a tank, or empty a tank completely.

Tasks

1. **Analyze the problem**: Define the environment (the three tanks), the possible primitive actions (full, empty, transfer), and the restrictions.
2. **Write a pseudocode** to resolve this enigma step by step.
3. **Validate the execution by showing each step within the tanks states** (water quantity inside each tank).
4. **Describe the algorithm** formally and verify if the solution is correct.

Objectives

This exercise requires to formalize the actions, define the initial and final states, and trace the step-by-step logical execution of the proposed solution.

Exercise 3: Organizing a sporting event

Statement

You are in charge of managing the organization of a sporting competition in your town. There are **08 teams** that will play a series of matches. The objective is to organize the matches in such a way that each team plays once against all the other teams. Describe the pseudo-code on how to organize the matches.

Objectives

1. **Analyze** the problem while clearly defining the actions to be carried out.
2. Write a pseudo-code algorithm in order to organize the matches.
3. Use the notion of **processor** while considering each team as an individual processor.

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4. Define the **environment**; here the tournament with the 08 teams.
5. **Validate** the algorithm by executing some steps.

Exercise 4: Optimization of the books sorting

Statement

You are asked to organize a library with a set of many books. The objective is to sort the books following the order and the size (from smallest to largest); however, you are not able to manipulate more than two books at a time. You can exchange the position of two books, no more.

Write an algorithm that allows to sort the books while respecting these rules.

Tasks

1. **Analyze the problem**: Describe the environment (a set of books and the possible actions: compare two books and exchange).
2. **Write a pseudocode** algorithm to realize this sorting buy using the primitive actions (compare and exchange) only.
3. **Describe the step-by-step execution of the** algorithm for a small set of books (for example, three or four books of different sizes).
4. **Validate** the efficiency of the algorithm et explain if it is optimal (does a faster way exist?).

Objectives

The students must think about how to model a simple process like sorting, while respecting specific constraints. They also must analyze and validate the proposed approach in terms of flow and efficiency.

Exercise 5: Traveler in a city

Statement

In a city, a traveler must visit three points of interest: A, B, and C. He starts at A, and must visit all three points and then return back to A by traveling the shortest possible distance. The distance between each pair of points is given:

- A → B: 10 km
- A → C: 15 km
- B → C: 5 km

Find the optimal route (with the shortest total distance) for the traveler visiting all the points.

Tasks

1. **Analyze the problem**: Define the environment (points A, B, C and the distances between them).
2. **Write a pseudocode** which explores the different possible routes and calculate the total distance for each traveler.
3. **Carry out the step-by-step execution** while considering each route and checking if it is the shortest one.
4. **Validate the algorithm** while showing that the found route is optimal.

Objectives

This exercise introduces the optimization and the combinatorial path, while respecting the concepts of analysis and actions formalization.

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Exercise 6: Planning a delivery route

Statement

A delivery man must deliver packages to 6 different addresses in a city. Each address must be visited only once and in an order that minimizes the total distance traveled. The addresses are numbered from 1 to 6. Write an algorithm to plan this route, describing in pseudo-code how the delivery man should proceed.

Objectives

1. **Analyze** the problem while defining the necessary actions.
2. Write a pseudo-code **algorithm** to plan the deliveries.
3. Use the notion of **processor** and represent the delivery man.
4. Define the **environment**, which is the city within the delivery addresses.
5. **Validate the** algorithm by executing some steps.

Exercise 7: Marienbad game

Statement

The Marienbad game is played using 17 matches. Each player may take 1, 2 or 3 matches each turn. The winner is the player who takes the last match.

Question:

How to be sure to win starting from the initial number of matches (17)? Build the corresponding analysis.

Exercise 8: Sequence of squares

Statement

Consider the following sequence: 1, 4, 9, 16, 25, ...

1. What is the next element of the sequence?
2. If you find the answer, build the analysis allowing to obtain an element from the previous one.

Exercise 9: Fibonacci sequence

Statement

Consider the following sequence: 0, 1, 1, 2, 3, 5, 8, ...

1. What is the next element of this sequence?
2. If you get the answer, build the analysis that allows obtaining the element from the two previous ones.